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SCIENTIFIC CONFERENCE ON PROBLEMS OF METEOROLOGY OF THE ANTARCTIC (ABSTRACTS OF REPORTS)

(USSR)

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SCIENTIFIC CONFERENCE ON PROBLEMS OF METEOROLOGY OF THE ANTARCTIC

(ABSTRACTS OF REPORTS)

(USSR)

Nauchnaya Konferentsiya po Problemam Meteorologii Antarktiki /Scientific Conference on Problems of Antarctic Meterology/, Moscow, 1959, Pages 3-48, Russian, pamphlet

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SECTION I. GENERAL PROBLEMS OF GEOGRAPHY

Basic Outline of the Topography of Eastern Antarctica

V. A. Bugayev, Candidate of Physical-Mathematical Sciences, Central Institute of /Weather/ Forecasting
Ye. I. Tolstikov, Candidate of Geographical Sciences, Main Administration of the Northern Sea Route

The Third Soviet Continental Antarctic Expedition made more than ten lengthy flights over Eastern Antarctica with the purpose of determining the altitude of the ice sheet. Two of these flights were made to the Pole of Relative Inaccessibility. The flights were made from Mirnyy through the South Pole to McMurdo /Sound/ and back on a straight line through Wilkes Land to Mirnyy.

Altitudes were determined by a specially developed method along the route every 25-50 kilometers, which made it possible to construct a number of detailed profiles of the Antarctic surface and also to make up the first relief map for an area embracing two thirds of Eastern Antarctica.

As the map shows, the highest dome of the ice sheet is 400-500 kilometers to the southwest of Sovetskaya Station. The greatest altitude here was on the order of 4000 meters. There is a well-delineated, wide intracontinental valley which begins near Sovetskaya Station and turns toward Olaf Pryuds /Transliterated/ Gulf. Two large spurs were discovered, one of which is directed from the cupola toward Mirnyy and the

other from the dome toward Victoria Land. The decrease in altitude toward the South Pole is smooth and there is an extensive depression in the vicinity of the pole with a diameter of 300 kilometers.

In its major outlines the relief of the Antarctic surface points out the peculiarities of topography under ice.

Many important phenomena of atmospheric circulation over Antarctica and its climate are explained well by the structure of its topography.

The Antarctic Ice Cap, Its Depth, The Topography of the Underlying Rock

Yu. M. Model', Candidate of Geographical Sciences, Institute of Geography of the Academy of Sciences, USSR
A. V. Nudel'man, Main Administration of the Northern Sea Route

The results of foreign explorations published up to this time and the data from three Soviet continental expeditions have already made it possible to obtain a general, quite complete idea of the thickness of the ice cover and the topography of the rocky bed in the Antarctic.

The first routine measurements of the ice from the shore into the depths of the continent were made from the Princess Martha Coast by a Norwegian-British-Swedish expedition prior to the beginning of the International Geophysical Year in 1949-1952. Explorations of American parties which were made in the summer of 1957-1958 included part of Western Antarctica between the Ross Sea and the Weddell Sea. The British Transantarctic Expedition crossed the continent from the Weddell Sea through the South Pole to the western shores of the Ross Sea.

The Soviet Antarctic Expedition, which began exploration of the interior areas of Eastern Antarctica in 1956, now has at its disposal materials which describe a large territory previously never visited by anybody. Measurements of the thickness of the ice, which were begun by A. Kapitsa (first section of the expedition), continued by O. Kondrat'yev, S. Lopatin, S. Manilov (second section), and carried on by O. Sorokhtin, V. Koptev, and Yu. Avsyuk (third section) up to the point of the geomagnetic pole (Vostok Station--1410 kilometers from Mirnyy and the vicinity of the Pole of Relative Inaccessibility (Pole of Inaccessibility Station --2110 kilometers from Mirnyy.

To the west of the cross-section obtained by Soviet explorers, measurements were made by the Australian Expedition, at a distance of approximately 640 kilometers south of the Mouson /Transliterated, apparently Mawson/ Coastal Base. At a distance of 320 kilometers from the

coast, the thickness of the ice turned out to be about 1520 meters. To the west of the area of Soviet explorations, the thickness of the ice was measured at the French Charcot Station, located about 300 kilometers from the coast. There is a report on measurements of the thickness of the ice cover several hundreds of kilometers south of the Charcot Station made by an American Air Party at Station C on Victoria Land.

The very recent thickness of the ice cover of Antarctica has been determined by different authors to average from 600 meters to 1500 meters. Soon after the beginning of explorations undertaken in accordance with the program of the International Geophysical Year, there was justification for considering these values underestimated.

Up to very recent times scientists were divided as to what the Antarctic ice cover was concealing under its depths--an archepelago of islands or a single continent.

After Antarctica was crossed by the British-New Zealand Expedition and Soviet explorers had made trips into the depths of the area, it was possible to state quite positively that an extensive continental massif was located under the ice cover.

Having at his disposal the data from Soviet Antarctic expeditions on the topography of the ice sheet, the geologist of the First Soviet Antarctic Expedition, P. Voronov advanced the statement that a series of highly-raised and sunken blocks were located under the ice cover, creating a system of depressions and mountain ranges in the topography under the ice. Explorations by the Third Soviet Antarctic Expedition yielded new facts which confirm the hypothesis.

At present the existence of block mountains and depressions have been established reliably by Soviet explorers from the coast of Antarctica at Olaf Pryuds Gulf to 80 degrees south latitude, that is, for a distance of more than 1000 kilometers, also by explorations of the British expedition in the vicinity of the south geographical pole.

As a result of the work of American explorers in the opposite side of Antarctica, data have been obtained which favor the existence of a depression under the ice which connects the Weddell Sea and the Ross Sea. The proposition of the existence of a depression which is a gulf filled with continental ice and which separates the continent into two parts which differ from each other in respect to structure, Eastern Antarctica and Western Antarctica, has been stated and refuted by different explorers since the time of the English expedition under Scott (1901-1904).

Continuing the exploration of Antarctica in accordance with the program of International Geophysical Collaboration, the Fourth Soviet Antarctic Expedition will prepare for explorations in the central areas of the continent. The projected trip through the three poles of Antarctica (magnetic, geographical, and pole of relative inaccessibility) will link the routes previously taken by Soviet explorers with the explorations of foreign scientists. This will permit obtaining material for ever more complete study of Antarctica.

SECTION II. THE ATMOSPHERIC CIRCULATION

Climatic Cyclone in the Western Part of the Indian /Ocean/ Sector of Antarctica

G. M. Tauber, Doctor of Geographical Sciences
State Geographical Institute

1. The Indian /Ocean/ sector of Antarctica is a region of intense cyclonic activity which is developed on polar and Antarctic fronts.

2. Polar front cyclones are formed in the region between 30 and 40 degrees south latitude close to the southeastern coast of South America (Atlantic branch) and South Africa (Indian Ocean branch).

3. Displacement of cyclones takes place in an easterly direction with a considerable southerly component. During the cold season of the year this component increases, which is linked with a more intensive distribution of sea ice to the northern and western parts of the sector than to eastern part.

4. Merging of cyclones of the Atlantic and Indian /Ocean/ branches is often observed southeast of Heard Island. Their regeneration on the Antarctic front causes further intensification of these cyclones. Thus the deep and extensive depressions typical of Antarctica are formed.

5. As a result of marked deepening, these depressions lose their mobility and are localized primarily in the region between 62-65 degrees south latitude and 80-90 degrees east longitude. Due to the high degree of repetition of such depressions, particularly in the winter and the spring months, a climatic central cyclone is formed here which is similar to the Iceland minimum in its stability and intensity.

6. The stability of cyclones in this region makes possible the crests of the Antarctic anticyclone which is formed in the coastal zone of Wilkes Land. These crests block the cyclones which come in from the west and the northwest.

7. An analysis of the data from Mirnyy and Mawson for 1956 provides evidence of the significant vertical power of the central cyclone. This cyclone is readily traced in all seasons of the year on the average monthly /weather/ maps AT_{700} and At_{500}, which were compiled in the Central Weather Bureau of the Antarctic in 1957. In some months it extends to a surface of 300 millibars.

8. The central cyclone west of the Indian /Ocean/ sector is an important factor in the climate of the whole equator of this part of the sector and the coast of Antarctica to the west of Knox Land.

A Theoretical Scheme of the Circulation of the Air Over the Antarctic

A. M. Gusev, Professor, Doctor of Physical-Mathematical Sciences, Institute of Applied Geophysics, Academy of Sciences, USSR

[Translator's note: The foregoing is in the form of notes and some of the sentences lack principal verbs. Due to the difficulty in supplying such verbs, the sentences will be translated as they appear--without the needed verbs].

The circulation of the air over the Antarctic, its physical analogs in the Northern Hemisphere and its share in the general circulation of the atmosphere of the terrestrial sphere.

The circulation of the air over the Antarctic is more accessible to theoretical and experimental study due to its symmetry. Thus it is a unique model of phenomena which are analogous but more complex in respect to configuration.

The special features of circulation, like the Antarctic, are the presence of two layers and inversion. The sources of circulation are permanent regions of increased and of decreased pressure.

The slope and the form of the surface of separation [interface] between the two layers of air and the possible fluctuations of this interface. The results of studies of fluctuations of the interface made by N. Ye. Kochin.

The general fluctuations of the cap of cold air over the Antarctic and calculations of the velocity, period, and value of horizontal displacement of the line of intersection of the interface with the surface of the earth, which is the line of the meteorological front.

The waves on the interface as mobile barometric formations. Experimental studies of the waves on the annular and circular interfaces and comparison of results with observations in the Antarctic and, in particular, with synoptic maps constructed for these regions.

An explanation of certain peculiarities of air circulation over the Antarctic from the standpoint of this statement and comparison of calculations with reality: the position of the Antarctic front, the paths of cyclones, the number and size of cyclones, velocities and directions of winds, the duration of storms in the Antarctic.

[Translator's note: The above appears to be a sketchy summary of some report. Perhaps this accounts for the choppy, verbless style of the text of the original].

Peculiarities of Summer Circulation and Weather in Antarctic Waters According to Observations on the Ob' in 1956-1957.

S. P. Khromov, Professor and Doctor of Geographical Sciences, Moscow State University imeni M. V. Lomonosov

During the voyages of the Ob' in 1956-1957, the author was able, for a more or less protracted period, to observe the weather in Antractic latitudes and to participate in the analysis of weather maps of the Southern Hemisphere on board the ship. In the report will be set forth the basic peculiarities of the summer and autumnal weather processes and weather conditions observed in Antarctic waters during this period. By comparing these observations with the results obtained previously by other authors, it is possible to draw some conclusions of more general significance in regard to circulation processes in Antarctica.

The summer season of 1956-1957 gives one an idea of the predominance of a zonal type of processes during the summer.

Cyclone formation on the polar front in latitudes north of 45 degrees latitude leads to the formation of barometrically weak disturbances which are intensified upon regeneration on the antarctic front where they lose the southerly component of their movement. The cyclones of the circle about the continent are primarily occluded or central. Stopping of the centers of the cyclones in the Indian /Ocean/ sector of the continent during the summer is practically excluded.

The subtropical anticyclones have a comparatively rapid displacement to the east. Atlantic anticyclones seldom cross South Africa, dying out to the west of that area. The formation of new subtropical anticyclones takes place during invasions of cold air into the western part of the Indian Ocean.

In the processes of cyclone activities, the antarctic front is shifted far from the continent. The comparatively rare discontinuities in the wind in the circle around the continent are linked rather with fronts within the Antarctic of secondary character between continental and marine Antarctic air. The sharp boundary of cloudiness and reduction in temperature in the immediate vicinity of the continent does not have a frontal character, but is connected with a change in the underlying surface and drainage circulation.

The difference in water-air temperatures in Antarctic waters is a very good criterion of stratification and the character of cloud formation.

A periodic changes in air temperatures over the ocean increase very markedly with altitude.

Other conclusions, including one in regard to the characteristics of the tropopause over Antarctic waters, will be given in a report.

Atmospheric Circulation in Antarctica and the Southern Hemisphere

O. G. Krichak, Candidate of Geographical Sciences
Central Institute of Weather Forecasting

1. A generalization of the weather maps of the Southern Hemisphere for 1957 and 1958 yield evidence of the uniqueness of the distribution throughout the hemisphere, especially its high latitudes, which are zones of cyclonic and anticyclonic activity. The position of the cyclonic zones close to Antarctica is determined by the configuration of the continent--orographic objects (peninsulas, large ice spurs) which jut out into the sea cause the formation of barometric spurs which block the cyclones which are moving around Antarctica, causing them to be stopped in definite, geographically determined places. The material we obtained from two years of observations agree well with Lamb's earlier data.

2. The anticyclone, which exists chiefly over Eastern Antarctica, is the characteristic peculiarity of atmospheric circulation over continental Antarctica. The material of 1957 and 1958 definitely emphasizes that this anticyclone is a high barometric formation, even though it does lose, in many cases, the form of closed anticyclonic isohypses at the altitude of 500 and 300 millibar surfaces and is preserved either as a high crest or a belt of higher pressure.

3. Displacement of the entire continent toward the Eastern Hemisphere also determines the displacement of the high Antarctic anticyclone in the same direction, and, correspondingly, the cyclones around the Antarctic. This is one of the most important causes for the formation of a zone of jet streams in the Atlantic-Indian /Ocean/ sector of the temperate latitudes, which also corresponds to a heightened tendency to cyclones (the roaring forties).

4. The existence of geographically conditioned regions of stationary cyclones around the Antarctic and of intermediate barometric crests also lead to a situation in which large meridional processes appear no less intensely than in the Northern /Hemisphere/ and the previously existing concept of a "wind barrier" should be considered obsolete.

5. The links discovered between atmospheric circulation and the ice conditions of the Antarctic seas permit one to hope for the possibility of approaching the problem of ice forecasting in Antarctic seas from analyses of the development of atmospheric processes.

Certain Peculiarities of Circulation and Structure of the Atmosphere in the Antarctic and the Central Arctic

S. S. Gaygerov, Candidate of Geographical Sciences

With the spread of aerological observations at great altitudes it is becoming clear that the significance of the polar regions in planetary circulation increases, so to speak, with altitude. The seasonal character of circulation in the stratosphere caused by radiation is spread practically through the hemisphere.

During the last decade Soviet aerologists have organized systematic aerological observations on drifting stations in the Central Arctic which permit making more accurate the existing ideas of the circulation and the structure of the atmosphere over polar regions. Aerological observations in the unexplored regions of Antarctica have been of equal significance.

Analysis of the observations made at isolated aerological stations in polar regions often require unique methods.

Observations made on Arctic drifting stations showed that cyclones, which frequently penetrate into the Central Artic, usually have a great deal of vertical power, a multilayered frontal structure, and turn out to be occluded. As a rule, fronts of occlusion extend to the tropopause and the great temperature contrasts on the fronts are often preserved to great altitudes. Tropospheric jet streams accompany intense cyclones.

The cyclones observed on the Antarctic coasts resemble the Arctic ones in respect to their frontal structure, but often turn out to be more intense. The basic distinguishing feature of the Antarctic cyclones is the effect of the easterly anticyclonic current in the lower layer of the atmosphere which leads, in particular, to a situation in which the occluded frontal systems do not reach the land as a rule.

The frequent development of meridional processes with blocking of east-west transportation, with stationary cyclones in orographically conditioned regions, is a special feature of the atmospheric processes in Eastern Antarctica. The blocking crests which are strongly developed over the continent transform the cold land Antarctic anticyclone into a high barometric formation.

The cyclonic circulation in the remote and high mountain regions of Antarctica is ordinary. Cases of penetration into these regions by cyclones developed in layers near the ground, also by frontal systems which carry clouds and precipitation along with them are not rare. Aerological observations will permit clarifying the peculiarities of these formations.

Both Polar regions of the Earth have a very similar character of seasonal changes in temperature and wind in the upper troposphere and the lower stratosphere, also in temperature and altitude of the tropopause even though there are differences. A more pronounced seasonal and annual course of the tropopause is observed in the Antarctic. Erosion of the tropopause in the winter is observed over both regions. The temperature and wind fields in the stratosphere in the Arctic appear to be more changeable. The Antarctic jet streams are more intense.

Differences in the temperature field of both polar regions at great altitudes are caused essentially by differences in the radiation balance.

On account of sharp differences in the orography, the character of the temperature field, and radiation conditions in the Arctic and the Antarctic, the atmospheric processes in the lower layers of the troposphere are scarcely comparable even though there are common features in the turbulent ground layer.

Air Masses in the Vicinity of Eastern Antarctica

Ye. I. Tolstikov, Candidate of Geographical Sciences, Main Administration of the Northern Sea Route

1. An increase in the number of meteorological stations during the International Geophysical Year and, in particular, the organization of a number of stations within the continent permitted the compilation of relatively complete daily weather maps throughout the whole of 1958. Painstaking analyses of these maps, also specially compiled calendars of circulation and air masses, maps of the paths of barometric formations, graphs of the vertical temperature distribution, etc., have facilitated the continuation of thorough study of the development of atmospheric processes.

2. The character of the weather in Eastern Antarctica is affected by not only the cyclones which occur on an Antarctic front, but also by cyclones which occur in temperate latitudes. During the summer the cyclones which occur on the Antarctic front are dominant during the summer while the cyclones of the front of the temperate latitudes are dominant during the winter. The cyclones which occur in the temperate latitudes are more intense, and their paths have a considerable meridional component. At times they penetrate far into the depths of Antarctica. The antarctic cyclones are less intense and they usually move along the edge of the ice from west to east.

3. Four basic types of air masses exist in Antarctica: continental Antarctic air (kAV), maritime Antarctic air (mAV), maritime air from the temperate latitudes (mUV), and tropical air (TV). mAV and MUV predominate in the Mirnyy region. The frequency of warm air masses increases noticeably during the winter, which provides evidence of increased meridional circulation during this period. Graphs of the vertical distribution of mean temperatures and graphs of the annual course of temperatures near the ground were constructed to describe the different types of air masses for Mirnyy. All the isolated types of air masses were also discovered in the central part of Antarctica, but the temperature of the air averaged 10-15 degrees lower than at Mirnyy.

The height of the tropopause in the coastal regions of Antarctica depended closely upon the type of air mass. Its lowest altitude was noted when kAB prevailed (about 8 kilometers) and the highest with TV (10-11 kilometers).

4. An analysis of material from wind observations (Bugayev, Rubin, and others) showed that at Mirnyy and at 10 stations located around Antarctica, on the average for the year, a current of air blowing out from Antarctica prevailed in the lower 1.5-2 kilometers while an inflowing current of air prevailed above 2 kilometers. The mass of air transported was very large. At the same time, according to all the stations, the influx of air into Antarctica was markedly greater than the amount of out-going air. It is obvious, nevertheless, that there are regions in which the amount going out should surpass the influx, but these regions are still not discovered and the problem requires additional study.

The Development of Weather Processes Over Western Antarctica

P. D. Astapenko, Lecturer and Candidate of Geographical Sciences, Leningrad Hydrometeorological Institute

1. The material obtained from meteorological observations in the Antarctic during the International Geophysical Year, as well as the experience gained in synoptical projects and flights in this geographical region show convincingly the exceptional importance of changes in weather conditions in the formation of the basic weather phenomena observed in the high latitudes of the Southern Hemisphere, including over the polar plateau.

Closer acquaintance with the course of all changes in the weather at the earth's surface and at altitudes accessible to instrument measurements in the free atmosphere indicates the frontal nature of the majority of these changes for stations located on the Antarctic coast and also indicates the preservation of the role of atmospheric fronts as the weather-forming factors for the continental stations of Western Antarctica, including the Amundsen-Scott Station located at the South Pole.

The appearance of atmospheric fronts as upper boundaries which seldom destroy inversion is characteristic of interior continental regions for a large part of the year when there exists an inversion close to the ground which is stable and very marked in respect to size and depression of temperatures.

2. The discovery of atmospheric fronts and tracing their movements in the Antarctic is rendered difficult not only on account of the known inadequacy of the network of stations, but also on account of the nonrepresentativity of the observations at the surface for the majority of stations whose data can be used for weather maps with great caution and by taking into consideration a number of corrections. This is true first of all of data on the temperature and the wind, also of visibility and observations of cloudiness during the polar night and twilight.

Under Antarctic conditions, time cross-sections of the atmosphere markedly facilitate the analysis of atmospheric processes, even though their compilation does not eliminate completely all difficulties in analysis. Those difficulties could be reduced to a minimum if there were a radiosonde network adequate for the construction of spatial vertical cross-sections of the atmosphere. However, there is as yet none in Antarctica.

3. Local weather phenomena at times appear to be very strong, but they themselves are linked with synoptical processes and are manifestations of regional peculiarities of the development of synoptical conditions. Their independence is merely apparent.

4. The geographical location and the topography of the Antarctic continent cause a great singularity in the development of cyclonic activity over the continent itself and over the seas which surround it. The compactness of the land mass which is raised high above sea level and its relatively symmetrical distribution around the Pole, the remoteness of other continents and large islands from Antarctica, also the comparative uniformity of the surface of the oceans surrounding Antarctica--all this has determined the existence of a ring-shaped track of depressions developing on an Antarctic front around the coast of Antarctica, likewise the numerous meridional tracks along which cyclones pass from the temperate to the high latitudes of the Southern Hemisphere.

The nonuniformity of the topography of the Antarctic continent, also the orientation of the sole significant peninsula which juts out to the north have determined the regions of increased activity of cyclones and the paths of movement of the cyclones over the continent as well as over the ice-covered sectors of the Antarctic seas which wedge their way into the land.

The role of the topography in the regulation of the life activities of cyclones over the interior regions of the continent, where the majority of the cyclones are tracked in the stage of filling up.

5. The great differences in the velocity of the cyclones which move in the Antarctic along different groups of paths and over different underlying surfaces merit special study. These differences in velocity bear witness to differences in the genesis of the cyclones, their membership in different branches of the main atmospheric fronts which exist in the Southern Hemisphere.

6. A separation of processes according to predominance of the effect of the Pacific or the Atlantic Oceans is characteristic of Western Antarctica, along with the two basic forms of atmospheric circulation (meridional and latitudinal).

To a considerable degree, the development of the processes depends upon the depth and the intensity of activity of the stationary depressions over the Ross Sea and the Weddell Sea as they appear at the level of the 700-millibar surface. With equivalent intensity of depressions over those seas, one observes advection of heat from the Atlantic to the continent and with more deeply developed depressions over the Ross Sea--from the Pacific Ocean.

A further, more detailed separation of the forms of Antarctic circulation or typification of the atmospheric processes of the Antarctic, depending on the mutual distribution and intensity of the four basic barometric formations examined at the same level of the 700-millibar surface, is also possible--of the anticyclone over Eastern Antarctica, the crest or anticyclone over Ellsworth Land, and the aforementioned depression over the Ross Sea and the Weddell Sea.

7. Cyclonic activity over the Antarctic has markedly more pronounced seasonal differences over the continent and the coast than over the Antarctic waters.

8. In the Antarctic, circulation conditions change considerably more from winter to summer in the stratosphere than they do in the troposphere. Here they surpass in absolute values the analogous changes known to us in the stratosphere over the high latitudes of the Northern Hemisphere. It is easy to find an explanation of this fact in the data which describe temperature fluctuations in the stratosphere. Even the mean monthly temperature over the South Pole (at an altitude of 20-25 kilometers) varied by 55 degrees from January to June 1958, a difference twice the seasonal differences in temperature at the surface of the ground and four times the difference in the middle troposphere at an altitude of 4-5 kilometers (extreme temperature values in 1958 over the pole were -93 degrees at the 30-millibar level on 17 July and -1 degree

on the 5-millibar level on 24 October). Maps of the 200-millibar and the 50-millibar levels show clearly the seasonal changes in atmospheric circulation over the Antarctic at these altitudes. Although the depression over the Antarctic was tracked the entire year on the mean monthly maps of the 200-millibar level, it was noticeable on the maps of the 50-millibar level only in the winter and the transitional seasons of the year, disappearing entirely during the summer.

9. One may also speak of the seasonal character of the stratospheric jet stream over the Antarctic which arises in the autumn, in March, when the atmosphere over the polar plateau become noticeably colder and the horizontal temperature gradients increase. The intensity of the jet stream grows in the winter; it reaches a maximum in the spring, in October, when the Sun returns and begins to warm the atmosphere over the northernmost regions of the Antarctic. This warming process, however, has not yet reached the plateau near the Pole. In November the belt of jet streams begins to shift to the South and its intensity is weakened. The center of the cyclonic vortex in the stratosphere during the winter is not over the Geographical Pole, but beyond the bounds of the western part of the continent, somewhere in the vicinity of the Pole of inaccessibility, that is, over the center of the continent. This indicates that at a height the circulatory and temperature conditions depend not only on the astronomical position of the sun, but also on the influence of the underlying surface.

10. Changes in the thermobarometric field of the troposphere in the Antarctic are reflected in fluctuations in the altitude and the temperature of the tropopause. This is true to an equal extent of both individual cases of sharp changes in synoptical conditions and seasonal fluctuations in the state of the atmosphere. Fluctuations of the altitude of the tropopause are observed the year round and are carefully tracked not only at the coastal, but also at the stations in the interior of the continent, in particular over the South Geographic Pole.

Cases of "disappearance" and "splitting" of the tropopause were observed better over the polar plateau than in other regions of the Antarctic in 1958. The first took place in the winter, the second in the transitional months from the winter type of tropopause to the summer, and vice versa.

Peculiarities of Temperature Conditions at /High/ Altitudes and Atmospheric Circulation in the Antarctic

Kh. P. Pogosyan, Professor and Doctor of Geographical Sciences, Central Institute of /Weather/ Forecasting

1. The regimes of temperature of circulation in the Arctic and in the Antarctic have much in common, but there is also an important difference. The common features are determined by seasonal radiation conditions and the differency by the character of the underlying surface and the temperature of advection.

According to observational data, the temperatures of the air through the entire year are 8-18 degrees lower over the Antarctic than over the Arctic. At the same time, the greatest value of this difference in the troposphere occurred at the 650-millibar level, which is explained by a significant cooling of the air over the icy plateau of Antarctica. In the summer, however, the temperature difference between the Arctic and the Antarctic approached zero at the 200-100-millibar level.

The difference between winter and summer temperatures over the North and the South Poles are also different.

2. The distribution of continents and oceans is such that the interlatudinal air exchange in the Northern Hemisphere takes place on a larger scale than in the Southern Hemisphere.

Winds over the North Pole are distinguished by greater velocities than over the South Pole. In the remote regions of Antarctica (Amundsen-Scott, Byrd) even in the winter the winds are comparatively weak, which also indicates the small-scale interlatitudinal exchange here.

Interdiurnal fluctuations in temperature constitute one of the indices of the intensity of interlatitudinal exchange and advection of heat to the Poles. The difference between the maximum and the minimum temperature in the North is markedly larger than in the South.

The horizontal transfer of heat to the North Pole takes place on a larger scale than to the South Pole, which is brought about by the difference in physico-geographical conditions and, in the first instance, the presence of Antarctica and the area of the ice about the continent.

3. The symmetrical arrangement of the ice zone and the constant cooling of the air masses which penetrate in from the middle latitudes should give rise here to a high cold depression with a corresponding system of circulation.

However, high wind velocities are also observed over Central Antarctica during certain periods. They appear chiefly when meridional exchange is intensified in the high latitudes, in connection with cyclonic and anticyclonic activity. Due to the differences in heat conditions, however, these processes take place in a different manner from the analogous processes in the Arctic.

4. In contrast to the Arctic, cyclonic vortices in the Antarctic cannot move about freely in circumpolar regions. An enormous obstacle --Antarctica with its ice sheet with an average altitude on the order of 2-3 kilometers--lies in the path of the cyclones which move in from the North. As a result, the cyclones are usually filled near the coasts of Antarctica and the air currents connected with them flow freely over the continent.

The structure of the field of pressure and the air currents in the Antarctic change continually since the atmospheric circulation in the Antarctic depends upon mocroprocesses over a considerable part of the Southern Hemisphere. However, the cyclones which come in contact with Antarctica are usually deformed in their lower layers.

5. As a result of extrapolating the field of pressure to the south of the surface centers of the cyclones often observed around Antarctica, an idea was gained of the existence of the so-called Antarctic anti-cyclone. In the meantime, both cyclonic and anticyclonic circulation take place freely over the ice massif of Antarctica.

The general outlines of this circulation at the 700-millibar and the 600-millibar levels, that is, directly over the ice sheet of Antarctica, are subjected to material changes in the lower stratosphere.

Frequent changes in the structure of the high barometric field and the character of the atmospheric circulation take place over Antarctica. Changes in the altitudes of isobaric surfaces reach hundreds of meters over Antarctica within short periods of time.

Cyclones which move along the coast with a component to the south have a more free access in the region of the Weddell, Ross, and Bellingshausen Seas which penetrate into the continent. Here they usually occlude and become high. Therefore, a cyclonic system of circulation is characteristic over these regions at [high] altitudes.

An Approach to the Study of Planetary Circulation With the Aid of the Properties of Macroturbulence

G. V. Gruza, Central Asian Scientific
Research Institute of Hydro-
meteorology

Study of the structure and fluctuations of the general circulation of the atmosphere is of great importance in the solution of the problems of long-range weather forecasting.

It is expedient to regard the general circulation of the atmosphere as a unified system of air currents of planetary scale. The energy of these currents is drawn from the potential energy of the heterogeneous temperature field. At the same time, the fact that irregular, random, or turbulent components of movement exist along with regular movements is a characteristic feature of the atmospheric movements which occur in general as a result of regularly acting causes (influx of solar radiation).

Therefore, an analysis of the hydrodynamic quantities analogous to those which are used in the theory of turbulence will be one of the methods for empirical study of the general circulation of the atmosphere.

For study of the most general properties of general circulation, the first step will be to study the zonal characteristics, that is, averaged along the latitudinal circles, of regular movements and macroturbulence. Study of their geographical distribution will be the second step.

The data obtained during the International Geophysical Year will permit conducting studies for the whole terrestrial sphere.

Study of the phenomena of the transfer of quantities of motion and heat will permit clarifying the causes of the formation of stable peculiarities of the general circulation and, in particular, the role of the polar regions, which will be corroborated by study of the processes in the Northern Hemisphere.

An attempt to compare the circulation in the Northern and the Southern Hemispheres will permit drawing preliminary conclusions.

The kinetic energy of the atmospheric movements in the Southern Hemisphere turned out to be about double that of the Northern Hemisphere.

The energy of the meridional movements has about the same value in both hemispheres, but the relative contribution of the meridional movements is larger in respect to the total energy in the Northern Hemisphere than in the Southern Hemisphere.

The exchange of a quantity of movement between the hemispheres is of great importance.

A comparison of the meridional heat currents permits clarifying the role of Antarctica as the planetary ice-box. The chilling role of the southern polar region (the Antarctic) in respect to the atmosphere has turned out to be greater than that of the northern polar region (the Arctic).

Certain Peculiarities of the Regeneration of Cyclones on the Antarctic Front

V. M. Shapayev, Professor and Doctor of Geographical Sciences, Leningrad Hydrometeorological Institute

1. A case of regeneration of a cyclone was investigated in the Indian /Ocean/ Sector of Eastern Antarctica while the Diesel-electric ship, the Ob', was there (14-19 January 1958). The results of the observations made on the Ob' have been compared with data from Pionerskaya /Station?/

2. The synchronism of changes in pressure of the same sign at these stations, which indicates the propagation of cyclone generation over a considerable area of the sea and the continent, is characteristic.

3. Irregularity in the absolute values of pressure changes creates an intensified cold current which follows in the rear of the cyclone, which intensifies the temperature contrast in it and leads to regeneration of the cyclone.

4. Warming /of the air/ above the continent makes it possible to stop this process. However, this warming of the air is itself a result of the activity of the cyclone, interacting with the continental anticyclone, one of the manifestations of which is the interchange of air masses.

SECTION III. THE RADIATION AND THE HEAT BALANCE, THE CLIMATE, AND THE REGIME OF INDIVIDUAL ELEMENTS

The Radiation Balance of the Snow Surface of Antarctica

N. P. Rusin, Candidate of Geographical Sciences, Main Geophysical Observatory imeni A. I. Voyeykov

1. Up to recent times the radiation regime in Antarctica was little known, therefore, new information is of great interest.

The processed data from Antarctic observations permit judging the components of the radiation balance on the littoral of Antarctica and on the slopes of the Antarctic plateau.

2. Total radiation (Q). Upon analysis of the data on total radiation called attention to an exceedingly high value for Q in the middle of the summer. During the warm period the daily totals of Q reached 800 and more calories per square centimeter at Mirnyy 900 calories per square centimeter at Pionerskaya Station, and more than 1000 calories per square centimeter at other stations in the interior of the continent. As for the monthly totals, they turned out to be greater than all known totals obtained for different points on the terrestrial sphere.

Even the annual total of Q at Mirnyy is comparable with the annual total of Q for the central belt of the European part of the USSR. On clear summer days the intensity of Q amounted to 80-85 percent of the maximum possible intensity calculated for these latitudes.

The large totals for Q in the Antarctic summer as compared with those for the same latitudes in the Arctic are explained by a number of reasons: great transparency of the atmosphere, a large number of clear days, high altitude above sea level, a large value for the albedo of the underlying surface and the clouds and the high secondary reflection connected with it, and increased solar radiation while the sun was at its perihelion.

3. Scattering of radiation (D). During the noon hours with a clear sky, the intensity of D amounted to 0.16-0.18 calories/square centimeter per minute at Mirnyy Station, that is, D amounted to 12-15 percent of Q.

On the slopes of the ice plateau the value of D during the summer months, with clear skies, fluctuated greatly, depending upon the altitude and the intensity of the snow cover or snowstorm. With completely

clear air, the intensity of D during noon hours amounted to 0.08-0.12 calories/square centimeter per minute, that is, merely 7-10 percent of Q. With a local snowstorm or a snowy haze, the intensity of D increased to 0.30 calories/square centimeter per minute, that is, amounted to 25-30 percent of Q. Maximum values of D were observed with high white clouds. In these cases the intensity of D differed only a little from the intensity of D with a clear sky (by 15-20 percent).

4. Direct radiation (S). Maximum values of S at noon, obtained by measurements on clear days, were observed in December and amounted to about 1.50 calories/square centimeter per minute on the coast and up to 1.78-1.80 in the depths of Antarctica.

According to absolute values, they turned out to average 6-7 percent greater on the coast than for the same latitudes in the Arctic. On the coast direct radiation on a horizontal surface amounted, on the average, to 40-50 percent in the spring and 50-60 percent in the summer. Averaged over the year, the share of direct radiation dropped to 40 percent, which is explained by the increased role of scattered radiation when the sun was low.

5. Reflected radiation (R) and albedo (A_k). The snow cover of Antarctica is distinguished by high capacity for reflection; as a result of this, its albedo is very high both in the winter and in the summer.

At Mirnyy the albedo turned out to be considerably lower than at Pionerskaya (60-85 percent), which is explained by a sharp change in the character of the underlying surface on the coast (snow - neve - ice) in the spring and in the summer.

In the summer the surface of the snow was covered with a very thin layer of ice, even at Pionerskaya Station, but still remained comparatively homogeneous; therefore the mean value of the albedo in the spring and the summer changed within limits of only 80-85 percent.

The minimum albedo at both points was observed in December.

6. Absorbed radiation (Q_p). As a consequence of the large values of the albedo, the absorbed radiation in Antarctica was comparatively small (20-25 kilocalories/square centimeter per year), that is, approximately one-half the annual total of the absorbed radiation for stations located on the same latitudes in the Arctic. On the coast of Antarctica the greatest monthly totals of Q_p were observed at the end of summer when the surface became icy, and in the interior of the continent--at the height of the summer when the largest amount of solar radiation reached the surface.

7. The radiation balance (B). Any region of Antarctica, if it is covered with ice or snow, has a negative radiation balance during the year.

By absolute values the annual balance amounts to -2 - -3 kilocalories/square centimeter on the coast at the latitude of the Polar Circle up to -7 - -8 kilocalories/square centimeter at Pinoyerskaya Station.

At Mirnyy the balance crosses zero in the middle of October and the middle of March, and at Pinoerskaya in November and February. Thus, a negative radiation balance is observed at Mirnyy for 4.5-5. months of the year and at Pionerskaya for 10 months.

8. The effective radiation (E_{ef}). The effective radiation is calculated as the remainder term of the equation of the radiation balance.

In the summer months at Mirnyy, when the temperature at the surface cannot go above 0 degrees but the temperature of the air may be a great deal above zero, the counter radiation of the atmosphere often turns out to be greater than the radiation of the snow and the effective radiation becomes positive during the day.

At Pionerskaya Station the daily course of E_{ef} decreases during the daylight hours and reaches maximum values in the morning and the evening.

Such an expense item in the radiation balance of the surface, connected with the effective radiation and supplementing the 75 percent loss of radiant heat due to the albedo on the coast and the 83 percent loss at Pionerskaya Station, constitutes the second reason for the negative annual radiation balance in Antarctica.

The Short-Wave Radiation Balance in the Troposphere and the Albedo of the Underlying Surface of the Antarctic Slope and of the Davis Sea According to the Results of Actinometric Observations From the Air

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When aircraft sounding /of the atmosphere/ was organized at Mirnyy, the following tasks were established in respect to the study of processes in the free atmosphere:

1) obtaining information on the changes in the basic meteorological elements with altitude at different seasons of the year under different weather conditions; 2) conducting actinometric and optical observations at different altitudes; 3) studying clouds (microphysical structure, liquid-water content, optical density, and other items).

In 10 months 17 flights were made, a considerable part of which were devoted to study of the actinometric and optical characteristics of the free atmosphere. The basic purpose of these explorations was to determine the rate of radiation heating of the air.

As a result of the actinometric observations made from the air over the Davis Sea and the Antarctic slope at different altitudes (up to 4 kilometers) during the summer, the following mean values of the rate of heating of the air in the troposphere due to absorption of solar radiation were obtained: over the sea, free from ice (150 kilometers from the coast), in the layer from 100 meters to 2 kilometers--0.034 degrees per hour, in the layer from 2 to 4 kilometers--0.026 degrees per hour; over the sea, covered with young ice, in the layer from 100 meters to 2 kilometers--0.023 degrees per hour, in the layer from 2 to 4 kilometers--0.010 degrees per hour; over the Antarctic slope (250 kilometers from the coast) in the layer from 2.2 to 4 kilometers the rate of radiant heating of the air was 0.033 degrees per hour.

These figures indicate that in the lower 4-kilometer layer the rate of radiation heating of the air in Antarctica is about 1/3 to 2/7 the rate of heating of the same layer of air for the western and southern regions of the USSR. It is well known that in the free atmosphere, when there is no cloudiness, the effective flux of heat (long-wave) radiation increases with altitude. This means that one is observing radiative chilling in the atmosphere under such conditions. Thus, it would be interesting to compare this value of chilling with the rate of heating of the air due to absorption of solar radiation.

By comparing the data on radiative heating of the air obtained on the basis of actinometric observations made from an airplane, with radiation chilling as determined by means of a radiation nomogram, one can conclude that radiation chilling and heating are of the same order over the Antarctic slope during clear weather. The mean value of radiation chilling over the slope in the 2-4 kilometer layer was about 0.4-0.6 degrees per day in March and 0.2-0.3 degrees per day in January. Over the ice-free sea (150 kilometers from Mirnyy, the value of radiation chilling in the layer from 100 meters to 2 kilometers was 0.1 degrees per day in January and 0.2-0.4 degrees per day in March. Thus, changes in air temperatures during the summer in the free atmosphere under our conditions is determined essentially by turbulent exchange and advection, not by radiative factors.

Mean values were calculated for the albedo for large areas of different underlying surfaces and for clouds of certain forms on the basis of data obtained from determining the density of flux of incident and reflected radiation by means of airplane observations. The mean value of the albedo of the Antarctic slope from Mirnyy to the 700-kilometer /Station?/ when the Sun's height was 25-35 degrees was 80 percent. A

decrease in the albedo was noted when the height of the sun decreased. In our case this is explained essentially by the fact that the presence of snow sastrugi is characteristic of the snowy surface of the Antarctic slope. When the Sun is low these sastrugi shade a considerable part of the snowy surface.

For young sea ice the mean value of the albedo is 65 percent. For the open surface of the sea the value of the albedo depends to a large extent on the height of the sun above the horizon and the state of the surface of the sea (degree of agitation). For example, above a sea with a quiet, smooth surface and with the sun at a height of 10 degrees, the albedo was 33 percent; when there were small waves and the height of the sun was 30 degrees, the albedo was 11 percent. The mean value of the albedo of stratocumulus clouds, which form over the sea more frequently than other forms under our conditions, was 62 percent. For altocumulus clouds with a thickness of 250-300 meters the albedo was 60 percent. Altostratus clouds, which predominate over the Antarctic slope, have an albedo of 40 to 60 percent on the average.

The material from the remaining types of airplane observations are now being processed and analyzed.

Turbulent Heat Exchange and Moisture Exchange in the Ground Layer of Air in the Antarctic

N. P. Rusin, Candidate of Geographical Sciences
Main Geophysical Observatory imeni A. I. Voyeykov

1. Antarctica is the only continent on the Earth where the annual radiation balance of the underlying surface is negative. Moreover, the temperature regime remains almost constant from year to year, or even has a tendency toward a warming of the climate on account of the intense turbulent heat exchange between the warmer inverted layers of air and the underlying surface.

2. The values of turbulent heat exchange calculated by ordinary meteorological and also special gradient observations at Antarctic stations for different periods of the year (L) made it possible to separate four zones:

a) Sections of the coast (shelf ice, shore ice, and others) which are not subject to the influence of katabatic winds on account of their geographical location. The annual total of turbulent heat flux here amounts to about -7 - -10 kilocalories/square centimeter per year;

b) Sections of the coast which are subject to the influence of drainage winds. The annual total of turbulent heat flux on these sections fluctuates from -12 to -20 and more kilocalories/square centimeter;

c) A large zone comprising the slope of the ice dome of Antarctica. The annual total of L here amounts to about 7-10 kilocalories/square centimeter;

d) The interior of the Antarctic plateau. The annual total of L here amounts to about -5 - -7 kilocalories/square centimeter. The turbulent heat flux in this zone is caused chiefly by the presence of large inversions and a great difference in temperature between the underlying surface and the air.

3. Since the ground layer of the air is almost always not only warmer than the underlying surface, but also more damp, an uninterrupted flux of water vapor flows down from above and is sublimated at the underlying surface in Antarctica.

4. Sublimation of the water vapor takes place both directly at the surface of the snow, causing the formation of precipitation in the form of hoarfrost, and also in the air, which leads to the rise of icy clouds, ice fog, or ice haze, which occasionally cover the stations located in the interior of the continent for weeks at a time. The coastal regions of Antarctica which are subject to the effect of katabatic winds, where evaporation replaces sublimation, constitute the only exception.

5. On the basis of calculations of the values of turbulent moisture exchange in the ground layer of the air and the possible amount of precipitation occurring on account of sublimation, it is possible to establish three zones: the coastal zone outside the influence of drainage; the coastal zone which is under the influence of drainage; and the interior continental which is characterized by a unique combination of the properties of evaporation and condensation (sublimation).

6. According to the calculations, the maximum possible value of sublimation for the central regions of Antarctica amounts to about 1.5 millimeters per day under winter conditions. In reality, though, the moisture content in the lower kilometer layer of the air averages 0.03-0.04 grams per cubic meter. If one then considers that the vertical velocity of the flux w 0.05 centimeters per second, then the value of the sublimating moisture will be approximately halved, that is, 0.7-1.0 millimeters per day.

These data are apparently close to reality. Thus, according to observations made at Vostok Station and Sovetskaya Station, 3 to 5 millimeters of precipitation fall per month during the winter due to condensation.

Climatic Zones of Eastern Antarctica

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During the International Geophysical Year, meteorological and aerological observations were made not only on the coast, but also in the interior of the sixth continent. As a result, we have data on the annual weather conditions at different distances from the coast, clear up to the South Pole.

Valuable material was collected likewise during flights and tractor-sled trips into the interior regions of Antarctica.

The observations show that the climatic conditions of Antarctica are closely connected with the main peculiarities of its topography. The latter are now known to us.

All this permits establishing the main climatic zones of Eastern Antarctica and the Southern Ocean which washes its shores.

These zones are as follows: a) the zone of the high Antarctic plateau; b) the zone of the Antarctic slope; c) the zone of drift ice; d) the zone of open Antarctic waters.

The climate of the continental plateau is not uniform, even though it does have such common features as the predominance of clear weather, little wind, dry air, a small amount of precipitation, and the lowest temperatures in the entire world. The lack of uniformity is determined by differences in the topography and the presence of the Ross Sea and the Weddell Sea which cut deep into the continent. The climatic zone of the Antarctic slope, which begins approximately at an isohypse of 2800 meters, is characterized by a significant rise in temperature as one approaches the coast, an amount of precipitation which is large for these cold places, and almost uninterrupted local snowstorms which are caused by drainage winds. The cyclones which pass along the Antarctic coast affect the weather of this zone.

The comparatively narrow coastal climatic zone can be divided into several characteristic climatic regions: a) the ice coast with barriers; b) Antarctic oases; c) the exterior shelf glaciers; d) the interior shelf glaciers; e) mountain ranges.

The weather of the zone of drift ice differs sharply from the clear and sunny weather on the continent of Antarctica. The weather over the drift ice is always gloomy and unstable. In respect to the circulation, this is the zone of activity of the Antarctic front.

Still farther North, beyond the bounds of constant propagation of continuous drift ice, it is expedient to define a separate climatic zone of Antarctic waters.

The climatic zones and regions cited above are described in the report in accordance with material obtained from observations.

The Mean Monthly Fields of Pressure and Temperature of the Air in Antarctica and the Southern Hemisphere

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1. In order to study the laws of general planetary circulation of the atmosphere it is necessary to make a detailed investigation of the barometric and temperature fields over the entire terrestrial sphere.

In order to clarify the basic characteristics of the thermal field and the barometric field, one can make use of maps of the mean values of these elements. Starting with this as a basis, work was undertaken to compile maps of the atmospheric pressure and the air temperature for all 12 months in accordance with the data of many years for the Earth.

2. The maps of means were constructed on data for 1881-1940. The selected period naturally cannot be applied to the entire terrestrial sphere, particularly to Antarctica and the regions of the Indian, Atlantic, and Pacific Oceans which are adjacent to the continent. As is well known, meteorological data covering the Antarctic have been very meager up to recent times. Only with the beginning of the second International Geophysical Year, when a more or less permanent network of weather stations was established, was it actually possible to undertake a study of atmospheric circulation over Antarctica.

Processing the material used was accomplished in accordance with methods suggested by the Main Geophysical Observatory, namely: the uniformity of series of observations was checked by differences between the closest pairs of stations, unreliable data were excluded, and data were reduced as far as possible to identical periods of many years' length.

3. The maps obtained permit clarification of certain special features of the circulation of the Southern Hemisphere, in particular, of the Antarctic.

The most characteristic feature of the atmospheric circulation in the Southern Hemisphere is the presence of belts of low pressure in the high latitudes along the coasts of Antarctica and of continual subtropical anticyclones in the low latitudes.

Six annual climatic centers of low pressure are to be found in the subantarctic depression which appears on the mean pressure maps throughout the entire year. Marked fluctuations in the intensity of different centers appear in individual months. In December, due to weakening of the meridional component and changes in the direction of movement of the cyclones, a supplementary cyclonic region is formed with its center somewhat northwest of the Balleny Islands. This region was tracked through the entire summer season. An increase in the frequency of cyclonic formations about 60 degrees South latitude, East of the South Sandwich Islands, leads to the appearance of a seasonal (spring) climatic center of low pressure. In the winter the average position of the subantarctic cyclonic zone is farther to the South.

On the mean [temperature] maps the isotherms of the Southern Hemisphere pass almost along the parallels for long distances and suffer sharp deviations only close to the continents. The greatest contrasts of temperature near the shores of Antarctica are observed during the cold months when a rapid chilling of the Antarctic continent takes place. Near the southern shores of America, Africa, and Australia the greatest contrasts of temperature are observed, however, during the warm months, which is caused by strong heating of the continents.

4. Mean values of air pressure and air temperature along the latitudes were obtained.

A double wave was discovered in the annual course of mean pressure, including the regions south of 40 degrees South latitude. The development of this double wave proceeds in different ways in different geographical sectors. The mean annual latitudinal values of pressure south of 55 degrees South latitude are in excess of 1000 millibars. The annual mean latitudinal values of temperature cross over to negative figures, beginning with 60 degrees South latitude. There is a sharp increase in the annual horizontal temperature gradients (about 2 degrees per 100 kilometers) in the latitudinal zone from 65 to 70 degrees.

On the Geophysical Grounds for Linking the Antarctic Low-Pressure Zone With the Belt of Antarctic Submarine Trenches

R. F. Usmanov, Candidate of Geographical Sciences, Central Institute of [Weather] Forecasting

1. The most characteristic feature of atmospheric circulation in the high latitudes of the Southern Hemisphere is a zone of low pressure which forms a belt around the continent of Antarctica through the entire year. From time to time this zone is interrupted by barometric spurs which occur along the main meridional spurs of the continent itself. This gives rise to localization of some climatic cyclonic centers that are distributed through this zone.

2. Climatic cyclonic centers are quite pronounced on the mean annual pressure map on which the thermal factors of the annual course [of pressure] are balanced and, as P. I. Brounov believes, mechanical factors emerge.

3. The cyclonic centers of the Antarctic zone of reduced pressure coincide closely with the main trenches (Bellinghausen, Australo-Antarctic, Africano-Antarctic) displayed on bathymetric maps. On the other hand, the zone of Antarctic convergence coincides closely with the Australo-Antarctic and the Africano-Antarctic subterranean mountains, also the South Antilles and the South Pacific mountain ranges. This provides evidence of a connection between the atmosphere and the lithosphere, which have compressibility as a common feature.

4. Denying the randomness of such coincidences, there are grounds for believing in the common nature of the causes of the formation of submarine trenches and regions of reduced pressure which, in our opinion, consist of the deforming forces of contraction of the Earth, which also lead to the existence of critical parallels on the terrestrial sphere. According to Stovas [Transliterated], even small changes in the rotational velocity of the Earth leads to important deformations of the Earth's crust, particularly in the zone of critical latitudes (0, 35, 61, and 90 degrees).

5. Taking into consideration the tendency toward slowing the rotational velocity of the Earth in our epoch, one may consider this slowing to be the cause of the formation of ocean depressions and the formation of Antarctica itself, inasmuch as there is tension in the zone of 61 degrees latitude and an elevation of the level in the vicinity of the poles.

6. The causes listed above cannot help but influence the atmosphere and the hydrosphere even though their effect will naturally be different on account of the differences in the properties of these media.

7. In contrast to the forces of the gradient of pressure, the Coriolis forces, the forces of friction and viscosity, the deformative force of the contraction of the earth always has a constant direction. Therefore, the role of these forces becomes paramount in periods of great length.

The Physical Causes of One of the Peculiarities of the Climate of the Interior Regions of Antarctica

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The comparatively small amplitude of annual fluctuations in the temperature of the air is one of the basic peculiarities of the climate of the interior regions of Antarctica. This peculiarity is explained by the unique heat conditions of the snow-ice cover of Antarctica.

In order to investigate this problem, we examined the propagation of temperature waves having a period of one year in the snow-ice cover stratum and calculated for various seasons the distribution of temperature gradients and the direction of the heat flux at different depths. With this purpose, the equation of heat conductivity is solved for concrete conditions:

$$\frac{\partial \theta}{\partial t} = \frac{k}{\rho c} \cdot \frac{\partial^2 \theta}{\partial z^2}.$$

The results of the calculations were compared with the data obtained from observations of temperatures made in depths up to 16 meters at Pionerskaya Station.

The results obtained from the calculations and the observations agree well and show that in the winter months the heat flux is directed upward from the ice layer to the surface and in the summer months in the opposite direction. This leads to some heating of the air by reserves of summer heat in the winter and cooling in the summer, which in turn, also leads to decreasing the annual amplitude of the changes in air temperature in the interior regions of Antarctica.

Characteristics of Drainage (Katabatic) Winds in Antarctica

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1. Katabatic winds constitute the characteristic feature of the climate of the coastal part of Antarctica.

2. The occurrence of these winds is connected with strong radiation cooling of the air on the slopes of the ice plateau and its movement down the slope under the force of gravity. Local topographical conditions and especially the peculiarities of the form of the surface

of the slope exert a significant influence on the strength of the katabatic winds and determine their direction. The region about Adelie Land (Cape Denison and Port Martin) can serve as a classical example of this effect. These phenomena are also sharply pronounced in the areas around Mirnyy and Mawson and in a number of other areas of the coast.

3. An analysis of the data from the Antarctic stations shows that in areas which are affected by katabatic winds the mean wind velocity is twice the normal value (not distorted by the topography) and in regions with strong katabatic winds 3.5 times the normal value. This value, which is computed from a large number of observations, is 5.5 meters per second. The results obtained could be useful in dividing Antarctica into climatic regions.

4. The intensity of drainage depends upon the cyclonic activity near the coast, over the ocean. In the forward part of the cyclone, drainage /katabasis/ is checked; but its highest intensity is observed in the rear part of the cyclone.

Crests of increased pressure and other aspects of a small-gradient barometric field constitute the most typical weather situations for katabatic winds. In these cases the direction of the katabatic wind does not always correspond to the direction of the pressure gradient.

5. Katabatic winds have a well marked annual and daily course; the latter is particularly clear-cut in the summer and in the transitional seasons.

6. The vertical thickness of katabatic winds is determined by the thickness of the layer of air chilled by radiation. Therefore, katabatic winds are always accompanied by inversions near the ice. The upper boundary of the inversion lies on the level of maximum weakening of the wind (300-500 meters). As a result of these inversions near the ice and also the small parameter of roughness of the snow cover in Antarctica, the coefficient of turbulent exchange is small in spite of the high wind velocity. The daily course of this coefficient is opposite that observed under other geographical conditions and corresponds to the daily course of the wind velocity. The maximum coefficient of turbulent exchange is noted in the evening and at night while the minimum is noted during daylight hours. In sections of the coast where katabatic winds are not observed, the coefficient of turbulence has the usual daily course.

7. The drainage of air along the ice slope causes an outgoing movement in the upper layers of the atmosphere, too, which favors drying of the air and scattering of cloudiness. The predominance of clear weather on the coast is connected with this phenomenon.

8. Observations made by the Soviet Expedition in 1956 from temporary mobile stations located in the vicinity of Mirnyy on the slope of the glacier and on shore ice made it possible to obtain not only qualitative but also quantitative ideas of the degree of the effect of the glacier slope on the climate of the coastal part of Eastern Antarctica. In particular, the boundaries of the spread of the katabatic winds over the sea, the effect of drainage on the angle of deviation of the wind from the isobar, the presence of foehn phenomena during drainage, the character of changes in the velocity of katabatic winds depending upon the steepness of the slope, the effect of drainage on the basic meteorological elements in the coastal part of the continent, etc., were established.

9. It was established that when katabatic winds are in the initial and final periods of their development they are distinguished by exceedingly great irregularity and are accompanied by sharp jumps in pressure, temperature, and humidity, creating a picture of air waves of short period.

10. An analysis of the observations by Soviet stations located on the coast and the interior of Antarctica permit suggesting that the drainage arises in the sector 90-100 degrees East longitude.

11. Katabatic winds sweep an enormous amount of snow from the surface of the continent and transport it to the sea. This snow remains in the zone where the katabatic winds die down, thus exerting considerable influence on the processes of cooling the sea and forming sea ice near the shores.

Peculiarities of the Topography of Eastern Antarctica in Connection With Weather Characteristics

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The recently acquired, but still limited information on the topography of Antarctica permits making the connection between the topography and katabatic winds more precise.

2. The velocity (V) of a katabatic wind, regarded as the descent of chilled air along a slope under the action of the force of gravity is determined by

$$V = \sqrt{2Sk\,\Delta\,g \sin \alpha},$$

where S - is the distance and α - is the angle of inclination of the slope to the horizontal, k - is the coefficient of proportionality, $\Delta\rho$ - is the deviation of the density of the air from its equilibrium values (in the absence of drainage), g - is the acceleration of gravity.

3. In order to analyze the connection between the velocity of a katabatic wind and the topography, the regions around Mirnyy and Oasis were taken in the first instance as the best described by hypsometric and meteorological data.

4. The altitudes above sea level (h) of many points determined during the last Soviet Antarctic expeditions permited establishing the increase in height of the cupola of the icy continent with the distance (S) from the coast analytically.

5. For the first 50 kilometers of the slope from Mirnyy in the direction of the katabolic winds (SSE) the following equation was obtained

$$h(S) = 18 + 42{,}13S - 84{,}3 \cdot 10^{-2}S^2 + 7{,}23 \cdot 10^{-3}S^3.$$

Exponential functions for different sections of this profile (altitudes at kilometer distances are shown in the subscripts of h) have the form:

$$h_{1,5-13} = 50{,}27\ S^{0,858} + 30$$

$$h_{13-50} = 158{,}1\ S^{0,4217} + 30$$

$$h_{50-100} = 23{,}02\ S^{0,907} + 30$$

$$h_{100-150} = 166{,}7\ S^{0,477} + 30$$

$$h_{150-640} = 243{,}3\ S^{0,4017} + 30$$

$$h_{640} = 687{,}4\ S^{0,2408} + 30$$

The equations for the Oasis region are analogous.

6. On the basis of the expressions obtained and by making use of the available observations for the winter months, the equation is justified:

$$V_n^2 - V_s^2 = 43{,}6 \cdot 10^{-3} \sum_{i=1}^{n} S_i h_i ,$$

where V_n - is the velocity of the katabatic wind at the coast, V_S - is its velocity at S kilometers from the coast, S_i and h_i - are the distance and the mean slope of the i-th section of the slope.

7. The distribution of velocities of katabatic winds along the slope from Mirnyy, presented in Table 1, was obtained by three methods on the basis of equations (3) and (4) and by the equations

$$V_S = 15 \sqrt{1 - 0,209 \cdot 10^{-3} \sum S_i h_i}$$

and

$$\frac{dV}{dS} = 1,875 \cdot 10^{-3} h'(S).$$

8. Making use of the data of G. M. Tauber and N. P. Rusin and inserting the coefficient of attenuation for the katabatic wind, one may judge the velocity of drainage in the Oasis region.

Table 1

Velocity of Katabatic Wind at Different Distances from Mirnyy

	Distance (in Kilometers)													
Method	0	10	20	30	40	50	75	100	150	200	250	300	350	380
1	15	14,5	14,2	14,1	13,9	13,7	13,2	12,7	12	11,5	11,1	10,7	10,2	10
2	15	14,4	14,1	14	13,7	13,6	13	12,5	11,7	11,2	10,7	10,1	9,7	9,5
3	15	14,3	14,0	13,8	13,6	13,5	12,8	12,2	11,6	11,2	10,8	10,5	10,2	10
Average	15	14,4	14,1	13,9	13,7	13,6	13	12,5	11,7	11,3	10,9	10,4	10	9,8

9. It turned out to be possible to extend the idea of the topography and to examine the connection between the latter and the velocity of the katabatic wind for the regions around Adèlie Land (140 degrees East longitude), Mawson Station (60 degrees East longitude), and Lazarev (13 degrees East longitude).

The general situation can be reduced to the following:

1) The altitude increases in accordance with an exponential law. The farther from the coast, the greater the distance which can be described by one [mathematical] expression.

2) In order to represent the topography of Eastern Antarctica, a detailed survey for meteorological purposes can be limited to a coastal zone 100-150 kilometers wide. At greater distances from the coast the survey can be of small scale or produced only along separate profiles which are of interest in some respect or other.

3) Changes in altitude in the direction of the katabatic wind can be evaluated by its velocity, even though this may not be acceptable in practice.

4) Katabatic winds range over a coastal zone which is several hundreds of kilometers wide in places. In this instance we have in mind katabatic velocities whose mean velocity is on the order of 10 meters per second and at times more than 15 meters per second over the coast in the winter. The combined action of the drainage /katabasis/ and the barometric gradient causes, as is well known, considerably higher wind velocities.

5) Persistent and strong katabatic winds in the wide coastal zone constitute a characteristic peculiarity of the Antarctic anticyclone. The latter is distinguished from the anticyclones of the temperate latitudes and the anticyclones of the Polar regions of the Northern Hemisphere by its weather conditions.

Research on the Electrical Field

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imeni A. I. Voyeykov

1. Study of the electrical field over the ocean. When the potential gradient is measured over the uniform surface of the ocean, it is possible to neglect the daily course of space charges and conductivity, which permits isolating the unitary variation in clear form. This work confirms the existence of unitary variation, even though a certain shift toward the morning hours is observed in approaching a minimum. Variations do not exceed 30 percent of the mean daily value of the potential gradient. When the potential gradient is taken along a latitudinal course, one observes a decrease in its values from 50 degrees of latitude in both hemispheres toward the equator and toward the poles. A peak was also noted between 10 degrees and 30 degrees South latitude which probably can be connected with storms in this region. Comparison of measurements of the potential gradient with barometric systems leads to the conclusion that the potential gradient is increased in the leading part of a cyclone and in the rear of an anticyclone while it is decreased in the rear of a cyclone and in the leading part of an anticyclone. This can be explained by upward and downward movements in corresponding parts of barometric formations. Clouds of the middle cloud sheet and the upper cloud sheet do not affect the value of the potential gradient. Clouds of the lower cloud sheet decrease it, depending upon the cloud cover, up to 30 percent.

2. Study of the electrical field in the Antarctic. Measurements were made at the Mirnyy Observatory. The potential gradient was recorded around the clock; currents from sharp points and space charges were measured episodically on days of strong snowstorms. Methodical work was carried out to make observations of these elements and material was obtained from uninterrupted observations over a period from 1958 through January 1959.

Lack of open ground and the uniform snowy underlying surface in Antarctica reduced the number of factors which cause variations in the potential gradient. The basic role is played by wind conditions, cloudiness, also the monthly and annual course of the potential gradient. Observations on clear, quiet days permit the isolation of unitary variation. An increase was noted in the positive value of the potential gradient with an increase in wind velocity from 5 to 35 meters per second. With wind velocities greater than 35 meters per second there was a jump in the potential gradient in value and sign which accepted large negative values that reached tens of thousands of volts per meter. Several flights were made to clarify changes in potential gradient with altitude.

The grounded network method was used to measure space charges. The density of space charges was calculated by Poisson's equation. Large positive and negative charges were noted which exceeded the values of space charges observed in thunderstorms by several times. The sign of the space charge depended essentially on the velocity of the wind, acquiring large negative values at wind velocities in excess of 35 meters per second. On days when there were snowstorms the current from sharp points located at a height of 10 meters was measured. The results obtained did not agree with the measurements obtained for the point effect under continental conditions. In Polar regions the point effect not only does not support, but on the contrary, weakens the negative charge of the earth. This conclusion supplements the data obtained by Vormele /Transliterated/ in stormy periods for Cambridge.

Conditions of the Formation of the Snow Cover in Antarctica (According to Data of the Second Soviet Continental Antarctic Expedition of 1957-1958)

I. D. Kopanev, Candidate of Geographical Sciences
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1. The thermal regime in Antarctica is determined by the radiation balance and the heat exchange between the atmosphere and the snowy surface with the latter taking the leading role.

Obtaining a quantitative description of the radiation balance is of great interest since it is included in the equation of the heat balance as a summary radiation characteristic, thus determining the energy regime of the upper layer of snow and the lower layer of the atmosphere.

2. Due to the great transparency of the atmosphere the flux of summary radiation in Antarctica in the summer is markedly higher than in the Arctic and even compares with equatorial latitudes. Significant losses of radiation heat are connected, first of all, with the great reflecting capacity of the snowy surface and also with the effective radiation.

3. Quantitative descriptions have been obtained of the thermal properties of snow, heat exchange and distribution of temperatures at depths, and the reflecting conditions of the formation of the snowy cover. The variation of thermal properties with time are not large, which indicates the weak intensity of development of thermal processes and phase transformations which take place in the surface layer of the snow.

4. The turbulent heat flux in Antarctica, in contrast with other regions of the terrestrial sphere, is downward, from the atmosphere to the surface through the entire year.

5. The moisture gradients in the layer of air near the ground are very small, which is a condition unfavorable for the condensation of water vapor and the precipitation of atmospheric moisture on the snowy surface.

6. As shown by experimental and calculated data, the expenditures of heat connected with evaporation under Antarctic conditions can be determined from the equation of the heat balance without great error.

7. Qualitative descriptions of the distribution of precipitation were obtained. Losses from the snow-ice mass are due not so much to snow being carried away by the wind and evaporation as to mechanical breaking off of glaciers which slip into the sea. On the coast the annual increment of snow amounts to a mean of 120-140 centimeters and in the central regions of the continent 35-55 centimeters.

9. The mean annual value of turbulent friction varies from 3.8 grams per centimeter-second^2 on the coast (Mirnyy) to 0.4 grams per centimeter-second^2 in the central regions (Vostok). The "critical" value of turbulent friction at which transportation of snow flakes begins turned out to be from 3.0 to 0.9 grams per sentimeter-second^2, respectively.

10. Our data do not confirm the conclusion of D. Mawson and F. Leve /Transliterated/.

The Formation of the Snow Cover in the Coastal Regions of Antarctica

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The snow cover shows the greatest diversity in the coastal regions of the continent, which is a consequence of sharp changes in the topography: a rapid increase in absolute altitudes, different exposure to solar radiation and the prevailing winds.

The character of falling solid precipitation shows a direct connection with the temperature. During the early autumn and the late spring precipitation consists chiefly of crystals of a laminated type of growth which is characteristic of temperatures not lower than -23 degrees Centigrade. Columnar crystals predominate in the winter. Averaged over the year, precipitation consists of 75 percent laminated crystals and 25 percent columnar crystals at Mirnyy. When a cyclone passed by Mirnyy, columnar crystals were replaced by laminar ones at the beginning and the reverse at the end.

The size of the falling crystals is linked, in the first instance, with the air temperature and the wind velocity. The mean size of the solid precipitation which fell in the vicinity of Mirnyy was 0.40 millimeters for the laminated type and 0.225 millimeters for the columnar type. The difference was connected with the temperatures at which they were formed and fell.

Two basic periods are characteristic in the formation of the snow cover--the cyclonic which provides material for precipitation and the anticyclonic which works over this material. The snow cover is formed by snowfall which occurs when cyclones exist which are accompanied by strong east winds and intense snowfall at a comparatively high temperature. The snow accumulates through snowfall and drifting of local snow. With katabatic winds, the absolute amounts of blowing in 1957 were greater than the accumulation. The mean velocity of katabatic winds during accumulation was 14 meters per second, and during blowing 19 meters per second.

During cyclones the increment of the snow cover reaches significant values. The maximum for six days (20-25 June) of almost continuous snowfall amounted to 44 centimeters.

In the coastal regions of the continent the formation of the snow cover takes place under the influence of the wind. A direct relationship was observed for general snowstorms between the intensity of the snowstorm i and the wind velocity V, which was expressed by the formula $i = 0.41V - 2.5$. Horizontal displacement of snow particles started with wind velocities of about 6 meters per second and when velocities were below this there was only snowfall not accompanied by displacement.

In addition to the strength of the wind, the state of the underlying surface is the basic reason for the intensity of displacement during local snowstorms. The minimum velocity at which snow begins to drift is: for a compact surface (hardness of more than 5 kilograms per square centimeter) 8 meters per second; for surfaces of medium compactness (hardness from 0.8 - 1.2 to 4 - 5 kilograms per square centimeter) 6 - 6.5 meters per second; for friable snow (hardness less than 0.8 - 1.2 kilograms per square centimeter) 4.5 - 5 meters per second.

At a certain time an increase in the wind velocity leads to a sharp jump in the intensity of the snowstorm which is a transition from strong drifting to a local snowstorm. At a time when drifting is being transformed into a snowstorm an increase in wind velocity of 1 - 2 meters per second results at times in an increase in intensity of 4 - 5 grams per square centimeter per minute. For a compact surface this jump takes place at about 16.5 meters per second, for surfaces of medium compactness at 15 meters per second, and for friable snow at 14.5 meters per second.

Rare cases of snow falling without much wind accompanying it (usually in the autumn) leads to the formation of a surface of friable fresh snow. The volumetric weight of such snow fluctuates within limits of 0.10 - 0.25 grams per cubic centimeter while the hardness is only 0.04 - 0.15 kilograms per square centimeter. The usual term of existence of fresh snow does not exceed a day.

Within a temperature range from -5 to -10, the volumetric weight of fresh snow δ is a proper parabolic function of the wind velocity V, as expressed in the formula $\delta = 0.104 \quad V - 6$.

The forms of the snow cover which occur as a result of the action of the winds are: freely accumulated forms (friable snow drifts; flat, sloping convex hillocks; and more compact and deeper snow drifts), forced accumulated forms (snow drifts and hills /Barkhany/, and eroded forms (sastrugi) and trenches).

In the coastal regions of the continent the process of accumulation of snow starts in the middle of February and ends 10-15 October. The course of snowfall during the year is irregular. The maximum accumulation takes place during the transitional periods, in the autumn (April-May) and in the spring (September-October).

The transportation of snow from interior regions is of some importance in accumulation of snow in the coastal regions. This is indicated by the following facts: lack of correspondence between the composition of falling and deposited snow crystals, the larger quantity of snow in the summer layers of trenches dug along the Mirnyy - 50-kilometer /mark/ profile as compared with the winter layers, and the different course of accumulation of snow in the vicinity of Mirnyy and at a point 7 kilometers from the coast.

In the final analysis, about the same quantity of snow accumulates along the entire coastal belt: close to the sea, on account of intensification of cyclonic activity, at a distance of 5 - 20 kilometers from the coast as a result of transportation of some snow masses from the interior parts of the continent. The total quantity of snow accumulated during the winter in the vicinity of Mirnyy in 1957 amounted to 766 millimeters of precipitation, and in 1958--595 millimeters of precipitation.

Consequently, the coastal regions are places of increased accumulation of snow masses as a result of intensified cyclonic activity and marked development of katabatic winds.

Certain Peculiarities of the Deposition of the Snow Cover of the Coastal Zone and the Zone of the High Plateau of Eastern Antarctica

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Snow accumulation in Eastern Antarctica takes place primarily in the solid form and the greatest precipitation occurs during the cold season when cyclones are active.

The outward apparent uniformity of the neve snow cover shows a great deal of diversity of physical properties when sections of its upper layer are analyzed. The ideas expressed in this communication are based on data obtained from sections of the neve snow layer taken at depts of 2 to 6 meters and data obtained from borings 18 - 55 meters deep in the vicinities of the stations at Mirnyy, the 250-Kilometer Mark, Pionerskaya, Komsomol'skaya, Vostok, Sovetskaya, and the Pole of Relative Inaccessibility, which provide an idea of the structure of the surface layer of the neve snow cover.

The characteristic feature of the sections is the alternation of layers of different thickness with peculiarities characteristic of each of them in respect to density, hardness, size of crystals, presence of bands of disintegration, and characteristic radiation and wind crusts (in the form of thin layers). One's attention is directed toward the clear-cut alternation between increased and decreased values of the density and the hardness of the neve snow mass.

Station observations (I. A. Ivanova, Yu. M. Kulakova) and field observations (Kh. Ya. Zakiyev) confirmed that during the year the maximum of density is connected with the spring-summer (warm) period and the lowest density is connected with the autumn-winter (cold) period. This proposition made it possible to make proximate separations of seasonal and annual layers /strata/.

The surface stratum of snow and neve, lying within the limits of 0.05 to 3 meters, is distinguished by the greatest friability and is usually composed of large-grained recrystallized snow. Concretions of grains are encountered. On the high plateau, particularly in the areas around Sovetskaya Station and the station at the Pole of Relative Inaccessibility, hoarfrost crystals are prominent in this stratum. The size of the crystals decreases below 7 meters. The density increases gradually below 3 meters. Hardness depends upon the degree of disintegration but decreases gradually with depth. Disintegrated sections, and in particular, radiation crusts are sharply distinguished by density and hardness.

Stratification has been traced to a great depth (more than 50 meters). Apparently each annual layer retains to some extent inherited physical properties to great depths. The neve snow layer is distinguished by great discreteness. The presence of a multiplicity of strata with a certain degree of retention, in the annual layer, of physical properties connected with indications of seasonality permitted the calculation of the number of annual layers in every section.

An attempt was made to calculate the approximate dynamics of the fluctuations in the amount of solid precipitation falling from year to year. This calculation was supplemented by observation data near the Vostok and Sovetskaya Stations, which permitted estimating from year to year the predominance of this or that type of atmospheric circulation and the type of weather in the interior regions of Eastern Antarctica.

Observation data and results obtained in respect to accumulation of snow in trenches near the 250-Kilometer Mark and Pionerskaya Station permitted us to note the existence of a complex process of assumulation of precipitation on the slope connected with the prevalence of a strong transportation of snow over the slope of Eastern Antarctica caused by the predominance of persistent, intensified wind activity which distorted the actual accumulation of precipitation on the slope. Over the slope there is a drift of accumulating snow toward the periphery, toward the edge of continental, ice-bound Eastern Antarctica.

On the Quantities of Ice Dumped Into the Davis Sea

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The calving of icebergs from Antarctica is one of the processes which reduces the size of Antarctic glaciers. As a result of processing material obtained from aerial photographs taken in 1956 and 1958 along the edge of the continental glaciation west and east of Mirnyy the amounts of ice dumped into the Davis Sea were determined.

The section under study extended from 82 to 110 degrees East longitude. Only the northwestern cape of Zapadnyy Glacier was excluded from the study because it could not be photographed on account of cloudiness.

Reproductions of preliminary compilations on a scale of 1 : 100,000 were used to determine the loss of ice from the northeastern part of Zapadnyy Glacier to the Ross Glacier. From the Ross Glacier on the east to the Vanderford Glacier (110 degrees East longitude) and from the northeastern part of Zapadnyy Glacier west to 82 degrees East longitude, the loss of ice was determined from aerial photographs on a scale of 1 : 50,000.

According to the measurements, the length of the section under study amounted to 2435 kilometers, of which the ice barrier occupied 523.5 kilometers (21.4 percent), /Vyvodnye/ /literally, "discharge"/ glaciers 347 kilometers (14.2 percent), and shelf ice 1564.5 kilometers (64.4 percent).

According to observations, the dumping of ice into the sea was not important for a distance of 1577.3 kilometers (64.8 percent), while active dumping took place for a distance of 857.7 kilometers, that is, 35.2 percent of the entire edge of the glaciation. During the year the total dumping of ice into the sea amounted to 447.8 square kilometers.

The dumping of ice for the year, broken down by individual glaciers appears to be as follows:

For a distance of 1564.5 kilometers along the shelf glaciers, the dumping of ice occurred for a distance of 367.5 kilometers and amounted to 190.4 square kilometers; for a distance of 1197 kilometers no dumping of ice into the sea was observed.

Discharge glaciers which occupied 347 kilometers of the coast dumped icebergs along a distance of 225.7 kilometers and the area of the icebergs dumped was 227.4 square kilometers. For a distance of 120.3 kilometers, no dumping of ice was observed.

The ice barrier extended for 523.5 kilometers, of which icebergs with an area of 30.0 square kilometers were dumped from 263.5 kilometers linear distance. However, for a distance of 260.0 kilometers no noticeable dumping of ice was observed.

During the year a strip 655.3 meters wide was calved from the discharge glaciers, a strip 121.7 meters wide was calved from the shelf glaciers, and only 57.3 meters from the ice barrier.

The most intense dumping of ice came from the discharge glaciers. The dumping of ice per unit of length of the glacier amounted to: for discharge glaciers 78.7 percent, for shelf glaciers 14.5 percent, and for the ice barrier only 6.8 percent.

The Radiation Balance of Certain Parts of the Atlantic and the Indian Oceans According to Observations Made on the Diesel-Electric Ship "OB'" in 1959

V. F. Belov, Candidate of Physico-Mathematical Sciences, Central Aerological Institute

During the voyage of the Diesel-electric ship "Ob'" from Mirnyy-Lazarev Station - Capetown - Murmansk, in addition to conducting a complex of meteorological and aerological observations, observations were organized to determine the components of the radiation balance of the underlying surface directly from on board the ship.

A Yanishevskiy pyranometer was used to measure the accumulated and reflected radiation and a thermoelectric Balansomer /Transliterated, possibly balansometer/ was used to measure the radiation balance.

The heat flux from each of these instruments was recorded with the aid of an electronic potentiometer.

All actinometric instruments were mounted on a special universal joint fastened to a 10-meter mast which moved forward with the bow of the ship. The instruments were nine meters above the surface of the water.

As the observations indicated, the universal joint almost wholly eliminated rocking of the instruments even during very heavy waves.

In order to exclude the effects of the wind from the balansometer readings and also to protect it from precipitation and drops of sea water, the receiving surfaces of the balansometer were covered with a thin polyethylene film which had approximately the same coefficient of absorption (about 7 percent) in both the visible and throughout the entire infra-red sections of the spectrum.

To process the results of observations, we first calculated the hourly, then the daily totals of both the accumulated and the reflected radiation, the radiation balance for the waters of the Indian Ocean which washes the shores of Antarctica from 93 degrees East longitude (Mirnyy Observatory) up to 13 degrees East longitude (Lazarev Station), and also for the eastern regions of the Atlantic Ocean (from the South Polar Circle to the North Polar Circle).

The values obtained of the daily totals of the accumulated and reflected radiation and the radiation balance, when reduced to corresponding tables and plotted on a map, permitted describing the radiation conditions of the above-mentioned parts of the oceans in the summer and in the transitional period of the year and to use them for calculating the heat balance in those seasons in these regions.

Experience in Approximate Determination of the Snow and Ice Balance in the Regions Under Study by the Soviet Antarctic Expedition (Eastern Antarctica)

Kh. Ya. Zakiyev, Candidate of Geographical Sciences, Rostov State University

The approximate determination of the snow and ice balance was based on observations of precipitation and the snow cover, also observations of snowstorms over a level area, evaporation, condensation, and thawing at Mirnyy and Pionerskaya Stations. Data from trenches and observations of the dynamics of snow accumulation, made during tractor-sled trips from Mirnyy to the Pole of Relative Inaccessibility, were also utilized.

Observations of precipitation were made with the aid of improvements suggested by G. M. Silin which permitted separating the precipitation which fell from above and that transported by local snow storms or drifting. Qualitative measurements of hoarfrost were made with the aid of a "laminar precipitation meter for hoarfrost" suggested by the author.

2. Information on the general trends in the flow of snow-ice masses in different regions of Eastern Antarctica was obtained from an analysis of hypsometric maps of Eastern Antarctica compiled by V. A. Bugayev and Ye. I. Tolstikov and from a profile of the fundamental bed of Antarctica obtained in accordance with seismological measurements and gravimetric measurements made by O. G. Sorokhtin, V. I. Koptev, and Yu. N. Avsyuk. Data taken from barometric hypsometry done by the author.

3. The materials obtained change the previous idea of the flow of the snow-ice masses which allegedly moved from the Pole to the periphery. Two outlet basins were separated within the limits of the area under study. The waterparting, or more accurately the snow-ice parting, passes between Sovetskaya Station and the Station at the Pole of Relative Inaccessibility at an altitude of about 4000 meters. From this ridge part of the flow is directed toward the Indian Ocean and part toward the South Pole.

4. Calculations of incoming (precipitation, sublimation) and outgoing (thawing, evaporation, wind transportation, dumping of icebergs into the sea) parts of the snow-ice balance yielded its approximate values for four zones: the coastal zone-- -31 cubic kilometers (in equivalent volumes of water), the slope zone-- +43 cubic kilometers, the transitional zone from the slope to the high plateau-- +4 cubic kilometers, and the zone of the high plateau-- +4.5 cubic kilometers. The total balance for the entire territory under study turned out to be positive; however, this does not negate the ideas based on more general data of a more probable gradual reduction of glaciation in Antarctica.

SECTION IV. METHODS OF OBSERVATION AND MEASUREMENT

The Value of the Temperature Correction /Required/ When Calculating the Geopotential of the 700-Millibar Surface According to Observations of Antarctic Stations

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1. The geopotential of the 700-millibar surface was calculated with great accuracy, on condition that the stations were supplied with mercury barometers, in accordance with observations made at stations located at an altitude of 2600-2800 meters (for example, Pionerskaya, Charcot, Amundsen-Scott). At these altitudes the pressure is close to 700 millibars and, consequently, the thickness of the layer between the station levels and the 700-millibar surface is small, about 100-200 gp. /Translator's note: Abbreviation not known, possibly hypsometric/ meters. Under these conditions, one can take the temperature at the station as the mean temperature of the layer without risking gross errors in determining the thickness of the layer.

Other circumstances are encountered at higher Antarctic stations such as, for example, Komsomol'skaya, Vostok, Sovetskaya, and the station at the Pole of Relative Inaccessibility (altitude 3400-3700 meters). Here the thickness of the layer between the station level and the 700-millibar surface is 800-1300 meters and the mean temperature of the layer should be determined in a special manner since the situation is complicated by the existence of a temperature inversion close to the ground.

2. Evaluation of the difference between the temperature at the station and the mean temperature of the layer, that is, the evaluation of the temperature correction, was done in accordance with /data from/ the interior continental stations at which radiosondes were employed. These were the Sovetskaya, Vostok-1, and the Pionerskaya Stations.

An emagram of the curve of stratification from the surface to the 300-millibar surface was constructed for each radiosonde. The curve moved down to the 700-millibar surface along those sections not disturbed by inversion near the ground. Then the mean temperature from the 700-millibar level to the level of the station was determined graphically. The desired temperature correction was calculated in this way for each sounding.

3. A good connection was established between the temperature at the station and the value of the temperature correction. The temperature correction increased with lowering of the temperature. The temperature correction depends somewhat more weakly on the altitude of the interior continental Antarctic stations since the altitude varies within limits of 500-1000 millibars on the interior plateau.

Method for Measuring the Radiation Balance From an Airplane

V. I. Shlyakhov, Candidate of Physico-Mathematical Sciences, Central Aerological Observatory, Fourth Soviet Continental Antarctic Expedition

1. Measurement of the radiation balance at different altitudes is of great importance in the study of the conditions for minimum temperatures, inversions, the daily course of temperatures, and other items. These questions are related to the problem of the transformation of air masses.

2. Special difficulties encountered in measuring the radiation balance from airplanes include the effect of the airplane on instrument readings, the effect of strong winds on the receiving surfaces of the instrument, buffeting, and changes in temperature and pressure with altitude.

3. We made use of a thermoelectric balansometer with a polyethylene filter mounted on a 1.5-meter angle bracket in front of the fuselage. The instrument was equipped with a stabilizer.

4. Three night flights were made by the Fourth Expedition over shore ice with cloudless skies up to an altitude of 4 kilometers.

5. On clear nights the balance of long-wave radiation was negative, this value decreasing with altitude.

6. The balance of long-wave radiation over shore ice and small floes was negative, but the absolute value was smaller for the first case than for the second.

Above the clouds the absolute value was double that below the clouds.

7. The following mean values of radiation chilling of the air were obtained: in the layer 0 - 1 kilometer - 0.09 degrees per hour; 1 - 2 kilometers - 0.05 degrees per hour; 2 - 3 kilometers - 0.04 degrees; and 3 - 4 kilometers - 0.06 degrees per hour.

Methods for Snowstorm-Measuring Observations in Antarctica

V. I. Shlyakhov, Candidate of Physico-Mathematical Sciences, Central Aerological Observatory, Fourth Soviet Continental Antarctic Expedition

1. The existing methods for measuring the transportation of snow, as was shown by preceding expeditions, are not suitable in the Antarctic. We designed and the workshops of the Fourth Soviet Continental Antarctic Expedition made a new device for cumulative measuring of snow storms.

2. The device for measuring snow storms is a hollow cylinder which rotates about a vertical axis with the aid of a weather vane; a silk bag is fastened to the lower end of the cylinder. The device was placed on the roof of a shed which was on the level of the surface of the snow and the bag was under the roof and inside the shed.

3. In order to study the transportation of snow at different levels by this principle, graduated snow storm meters of smaller sizes were made, and fastened to a sloping mast at heights from 0.5 to 5.0 meters.

4. In order to determine the altitude of the upper boundary layer of local snowstorms, a ceiling projector was used with a base projector range of 145 meters.

5. With wind velocities of 6-10 meters per second, the height of the local snow storm layer fluctuated from 1 to 5 meters, with wind velocities of 15-18 meters per second--12-16 meters, with winds of 19-22 meters per second--25-28 meters. With gusty winds of 5 to 31 meters per second the height of the snow storm layer fluctuated from 1 to 90 meters.

6. In July 1959, during 28 days of snowstorms, 380,199 kilograms of snow passed per linear meter of coast (the line extending from the continent to the ocean) with an average wind velocity of 11.8 meters per second. The maximum quantity of snow passed through on 29 July (110,062 kilograms with an average wind velocity of 22 meters per second.

Barometric Altimetry in Antarctica

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While we were in Antarctica, we used geodesic and barometric methods for levelling. The geodesic method was used to determine the altitude of triangulation points only. In all other cases, altitudes were obtained by barometric altimetry.

The barometric method for determining altitudes took into full consideration the state of the atmosphere. The state of the atmosphere over the icy continent determines the peculiarities of barometric altimetry. The systematic stratification of the atmosphere permits one to assume that it is possible to make successful use of the barometric method of altimetry.

The barometric method of altimetry was used to determine the altitude of surface points in field geophysical and glaciological explorations and to determine the zero altitude for the barometers belonging to the interior continental stations.

Altitudes were calculated by the well-known formula

$$h = \frac{8000}{B_{cp}} \left(1 + \alpha /_{cp}\right) \left(B - B_1\right),$$

where B - is the pressure at a determined point; B_1 - the pressure at the initial point; t - is the temperature at a determined point; t_1 - is the temperature at the initial point; B_{sr} - is the mean pressure, equal to $\frac{B1 + B}{2}$; t_{sr} - is the mean temperature, equal to $\frac{t1 + t}{2}$; $\alpha = 0.003663$. For excesses above 500 meters, corrections are calculated, the formulas for which are obtained after transforming the complete barometric formula of Jordan.

The calculated barometric altitudes are corrected for the incline of isobaric surfaces. As a result of compensation, the following altitudes of supporting points were obtained with mean square errors calculated with internal convergence:

[Station]	[Altitude]	
150-Kilometer	1734	± 18.9 meters
225-Kilometer	2093	± 5.2 meters
Pionerskaya	2700	± 3.6 meters
Vostok 1	3290	Obtained by a meteorological party of the Second Expedition
Komsomol'skaya	3435	± 9.2 meters
Vostok	3441	± 5.2 meters

The mean square error for determining the altitude of a point in respect to the points surrounding it is $M = \pm \sqrt{\frac{m^2}{n}} = \pm 12.1$ meters. The error in determining the slope of the isobaric surface can also be material. The altitudes of intermediate points along the trip were correlated respective to the supporting points.

It is necessary to note the good convergence of our results with the determinations of altitudes obtained by O. G. Krichak (he obtained an altitude of 2700 meters for Pionerskaya) and V. A. Bugayev (for Pionerskaya--2704 meters, Komsomol'skaya--3416 meters, and Vostok--3416 meters).

If follows from an analysis of the calculated altitudes, however, that the complete barometric formula does not take into consideration all the peculiarities of the state of the atmosphere. Thus, the altitudes of some points, calculated according to hourly [synoptic] observations differ from each other. At the same time, the deviation from the mean should be obtainable from some law by tying in deviations of altitudes with changes chiefly in temperature.

A more complete study of the barometric method of altimetry is possible on a geodesic basis, with simultaneous comparison of meteorological observations and aerological sounding of the atmosphere. By making use of geodesic and barometric altitudes on a profile and [the results from] lengthy meteorological observations made at stations, it is possible to find some patterns in the changes in the barometric field, the influence of the temperature field, and so forth. Only after this work [has been done] will it be possible to determine more reliably the altitudes of all the interior continental stations, which also means trustworthy weather maps and the altitudes of field investigations.

Projects on Aeroradio Altimetry Carried Out During the Second Soviet Continental Antarctic Expedition (1957)

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1. The acute need for obtaining information on the altitudes and the topography of Antarctica has compelled the meteorologists themselves to undertake to solve this problem inasmuch as the usual geodesic projects have not as yet been carried out on a large scale in Antarctica.

2. In our opinion, the almost constant existence of a deep inversion of cold in the lower atmospheric layer over Antarctica excludes the possibility of extensive use of barometric altimetry.

3. The method of aeroradio altimetry turns out to be the one most suitable for Antarctic conditions; however, we used it in several modified forms.

4. Flights were made chiefly on the upper boundary of the temperature inversion. The altitude of the airplane over sea level was determined from continuous recording of a meteorograph, while the altitude of the airplane over the surface of Antarctica was determined at different points by a radio altimeter. The difference in these values gave the altitude of the locality above sea level.

5. In order to reduce errors, both instrumental and in calculation, meteorograph charts were made for two directions, from the take-off point to the landing point and in the opposite direction, after which average values were used. The final results determined from calculations based on repeated measurements over the very same points were also averaged.

6. We could not exclude wholly the error caused by the existence of a horizontal barometric gradient; however, the flights were usually made with the isobar in a meridional position that coincided closely with the direction of flight, which reduced error considerably.

7. In later projects, measurements of altitudes should be made over all of Antarctica with data on its topography. Moreover, it is necessary to obtain repeated measurements at the same points for systematic improvement of hypsometrical maps. Therefore, it is important to apply the most thoroughly tested methods, naturally taking into account future improvements in methods.

Methods for Determining Altitudes of the Surface of Antarctica Which Were Used by the Third Soviet Continental Antarctic Expedition

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1. Three methods were used for determining the altitude of ice-armored Antarctica: topographical surveying, barometric altimetry according to observations made at meteorological stations and aeroradio altimetry with the aid of an airplane. The first method is of very limited application since it is linked with great difficulties. The second method, which yields sufficiently reliable results, can be used for finding the altitudes of only a small number of points where station meteorological observations are conducted; these altitudes are used in the third method as control points. The third method, even though it is less precise, is the most suitable as it permits determining the latitudes over lengthy trips over any of the reaches of Antarctica in a short time.

2. We made the following synchronized observations in order to make calculations by the method of aeroradio altimetry:

a) Determination of the altitude of the airplane above sea level with the ordinary altimeter.

b) Determination of the temperature of the atmosphere at the flight level in order to derive the temperature correction for altimeter readings.

c) Determination of the altitude of the airplane over the location with the radio altimeter.

d) Use of radiosondes at stations located on the course of the flight or relatively close to it.

3. These observations provide two independent series of altitudes of the airplane above sea level: a) those obtained from the altimeter after inserting the correction for temperature of the atmosphere and b) those taken from graphs of radiosone ascents in accordance with pressure values noted with the aneroid /barometer/. The two series of altitudes are compared and if the deviations do not exceed $\pm$ 20 meters, they are accepted as final. We took the altitudes obtained with the altimeter as basic. Radiosonde altitudes were considered as control. In case there were differences in excess of $\pm$ 20 meters, possible corrections were studied.

The desired altitudes of points on the surface of Antarctica were obtained by subtracting the radio altimeter readings from the altitude of the airplane above sea level. We made synchronized records (without the use of radiosondes, of course) every five minutes during the flight of the IL-12, which gave intervals of 20-25 kilometers between points. The records were made still more frequently over complex topography. Frequent reports led to a supplementary control of altitudes when outlining a profile of the surface.

4. Errors in determining altitudes by the method of aeroradio altimetry amount to errors in utilizing the altimeter, radio altimeter, aneroid barometer, and the radiosonde. Errors in recording had a value on the order of ± 10 meters. Special requirements were presented in correct evaluation of air temperatures. On lengthy flights the use of radiosondes should be made not less than twice daily, enlisting coastal and interior continental stations, and the calculations of altitude require corrections for the nonhorizontal nature of isobaric surfaces.

In case of an unfavorable combination of signs of all the above errors, the total error in determining altitudes of points may reach 50 meters. However, the error in determining altitudes by aeroradio altimetry should not exceed - 20 meters.

An Approach to Determining the Absolute Altitudes of the Icy Dome of Antarctica

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Determining the topography and altitudes, and the construction of hypsometric maps of Antarctica is one of the basic tasks in studying the sixth continent. This problem is an independent geographical problem, but its solution is linked with the solution of still other problems--meteorology, glaciology, and gravimetry.

The difficulties encountered in solving this problem are caused by the impossibility of using instrument surveying on the required scale and the inaccuracy of barometric altimetry brought about by the complex atmospheric pressure field.

A method [was developed] to determine the altitudes of the icy dome of Antarctica which permitted exclusion of the effect of the irregularity of the pressure field and observations were made with this method in Antarctica by Soviet expeditions.

A method [was developed] which was independent of determinations of atmospheric pressure. This method was based on integration of vertical accelerations and displacements of the airplane and flight altitudes over the dome were determined with the aid of a radio altimeter.

Altitudes were determined by these two methods during the Third Expedition and the beginning of the work of the Fourth Expedition. A report will present a description of this work, the results, and a comparison of values of altitudes obtained by different methods.

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